National Renewable Energy Laboratory

Update on Testing Activities at NREL DER Test Facility

Ben Kroposki, NREL

Distributed Power Integration Engineering and Testing Lead

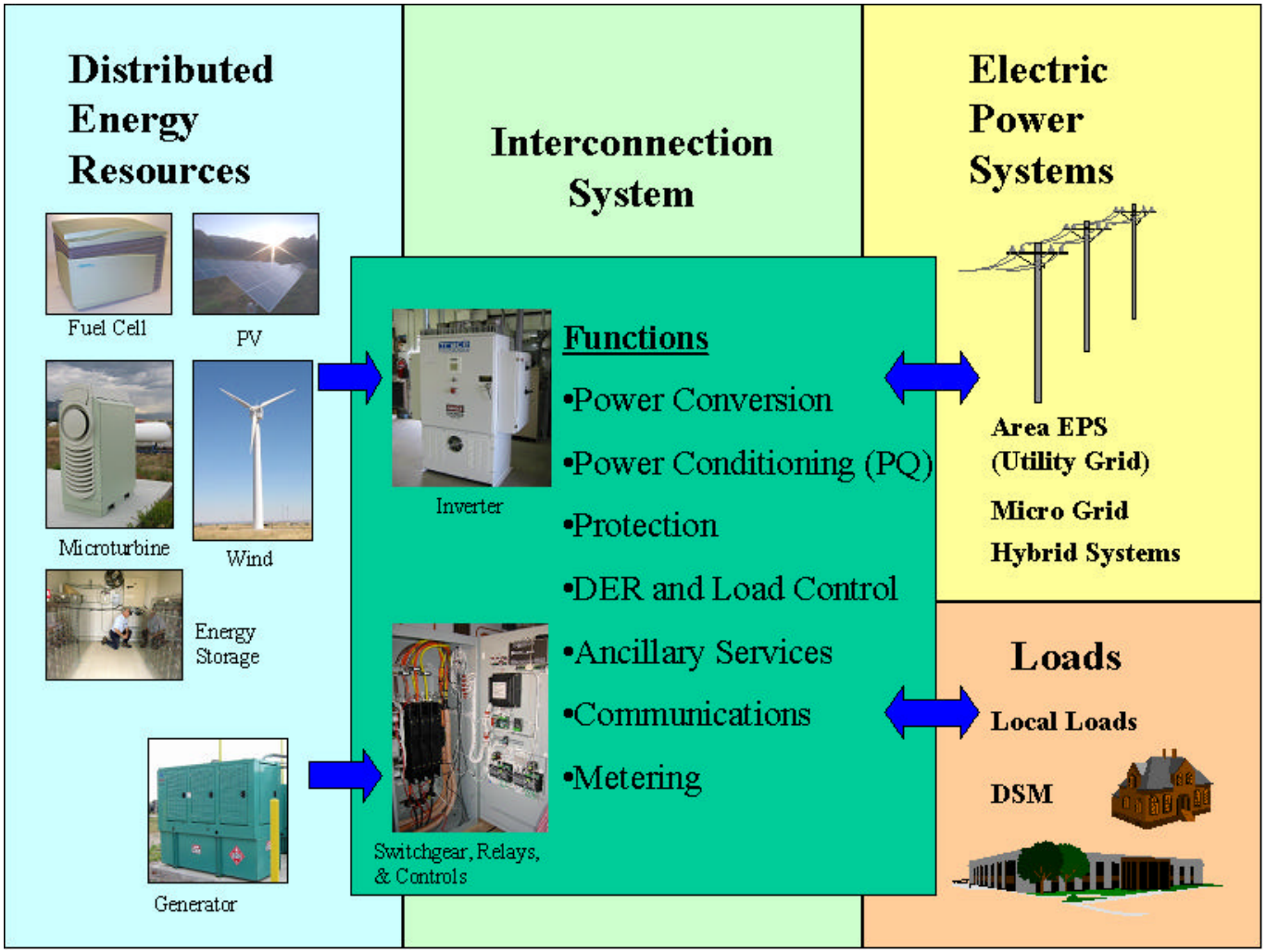
Distributed Power Program
Review Meeting

July 9-10, 2002

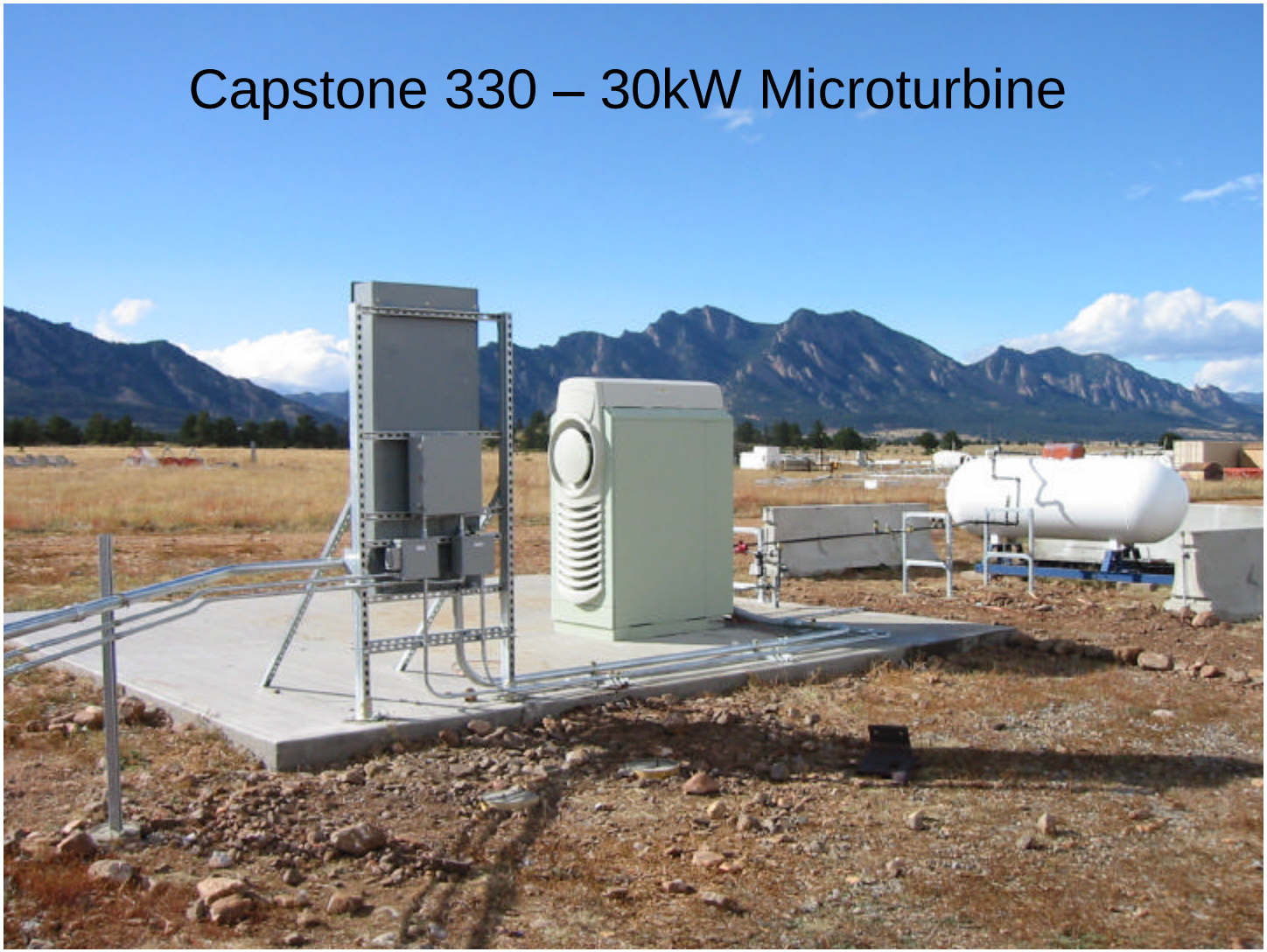
Madison, WI

NREL DER Test Facility – Boulder, CO

DER Interconnection System



Capstone 330 – 30kW Microturbine



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NREL Test Facility
Interconnection and Systems Integration Testing

200kW Grid Simulator – Simulate utility grid and full control of voltage and frequency to test DG response to grid distrurbances

Yokogawa PZ4000 - Power analyzer – For Data Acquisition and measurement

Capstone 330 – 30kW Microturbine running on Propane

Load Banks

PCC

IEEE P1547 Requirements

Over and Under Frequency

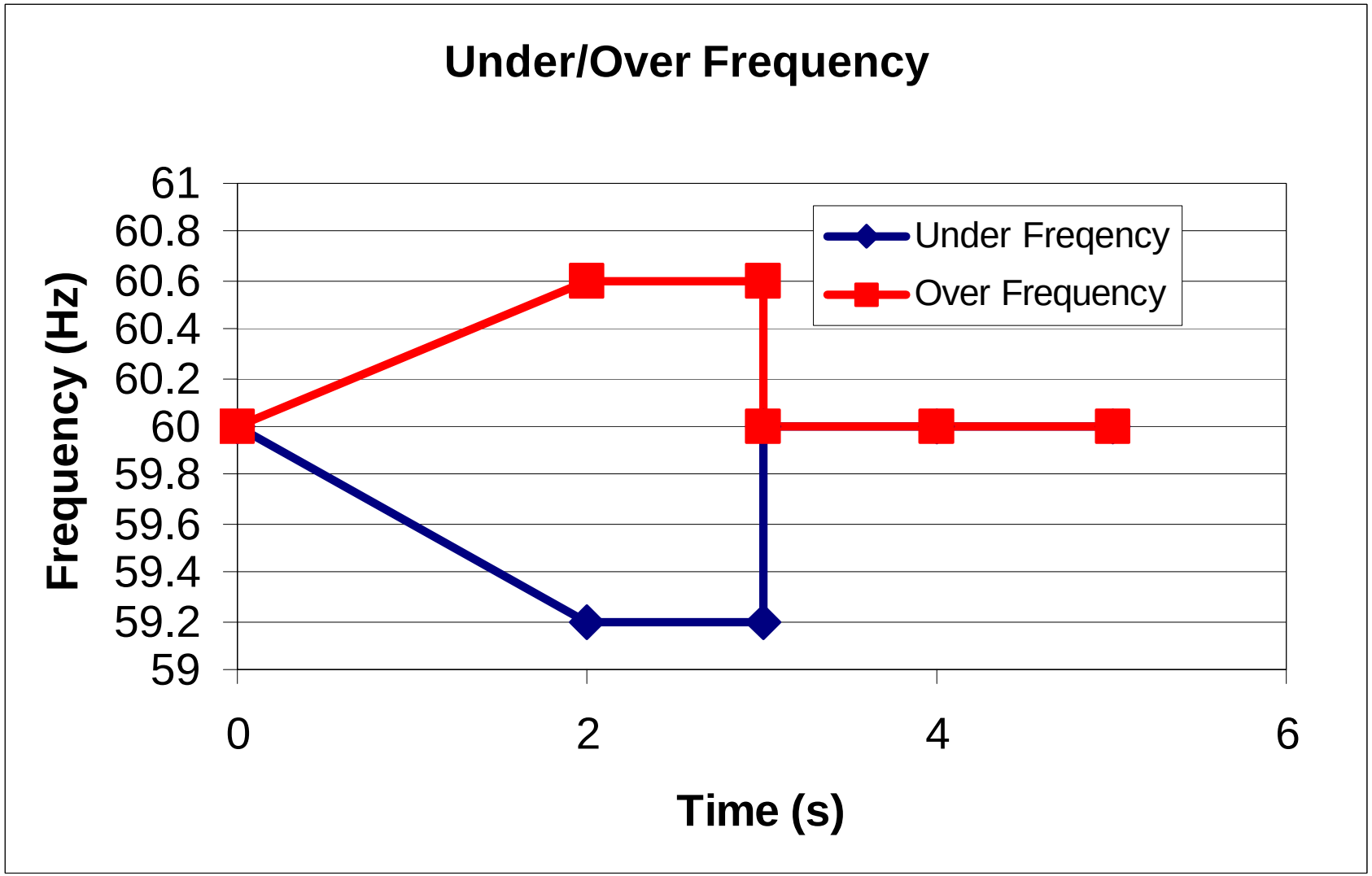
Must disconnect within 0.16s for frequency over 60.5 or under 59.3 Hz.

Over and Under Voltage

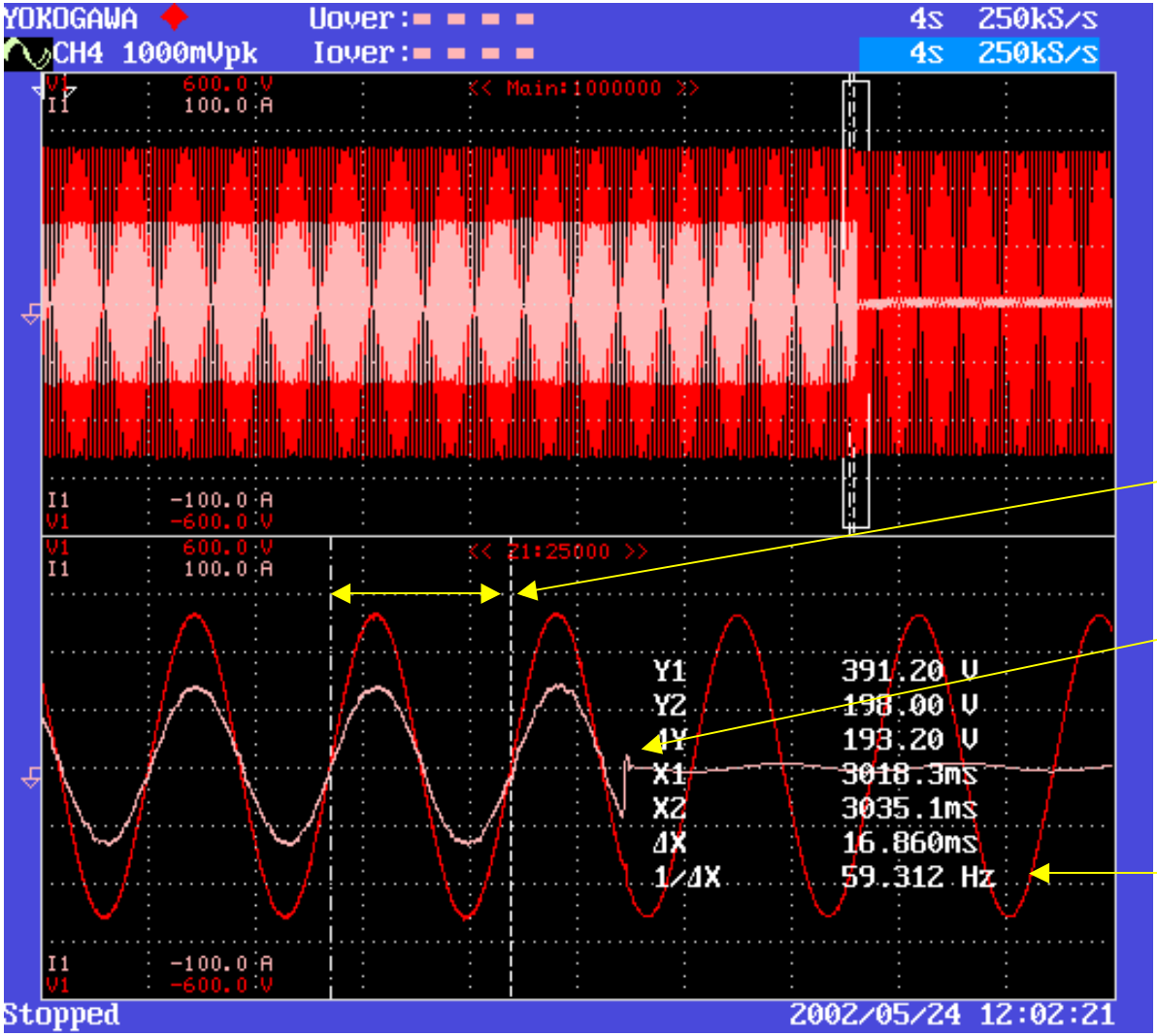
Voltage Range (% of base voltage)	Clearing Time (s)*
V< 50	0.16
50 <=V≤<88	2
110<V<120	1
V ≥ 120	0.16

Anti-islanding

DR must disconnect within 2 sec. After formation of island.


Under/Over Frequency
Frequency (Hz)
61
60.8
60.6
60.4
60.2
60
59.8
59.6
59.4
59.2
59
0
2
4
6
Time (s)
Under Freqency
Over Frequency

Under Frequency Test Results



Test: Under Frequency

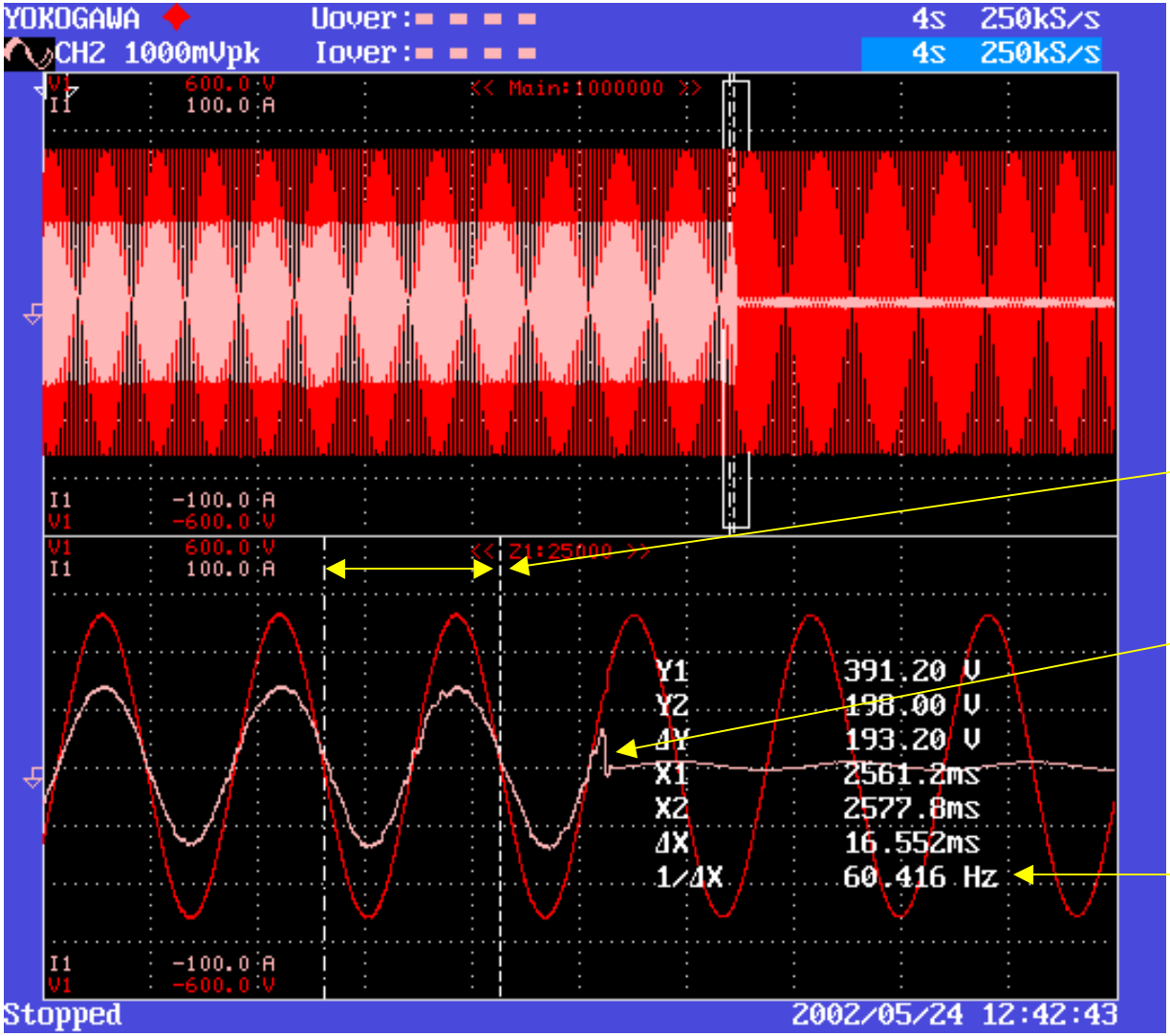
	Setting	Trip Freq
1	59.3	59.40
2	59.3	59.27
3	59.3	59.40
4	59.3	59.37
5	59.3	59.31
AVG	**59.3**	**59.3**

Measurement Period

Point of Disconnection

Frequency at disconnect = 59.312 Hz

Over Frequency Test Results



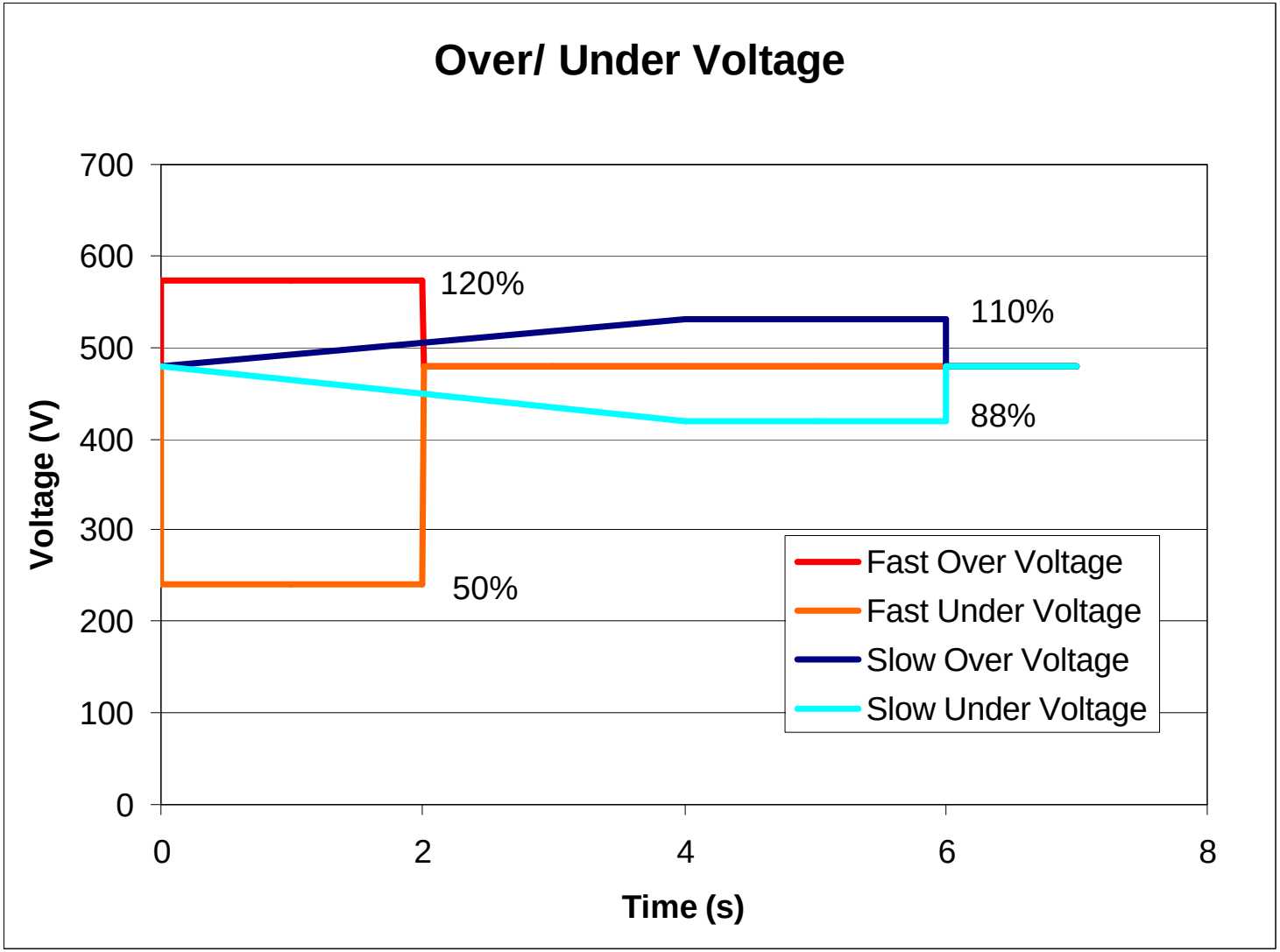
Test: Over Frequency

	Setting	Trip Freq
1	60.5	60.55
2	60.5	60.42
3	60.5	60.49
4	60.5	60.49
5	60.5	60.53
AVG	**60.5**	**60.5**

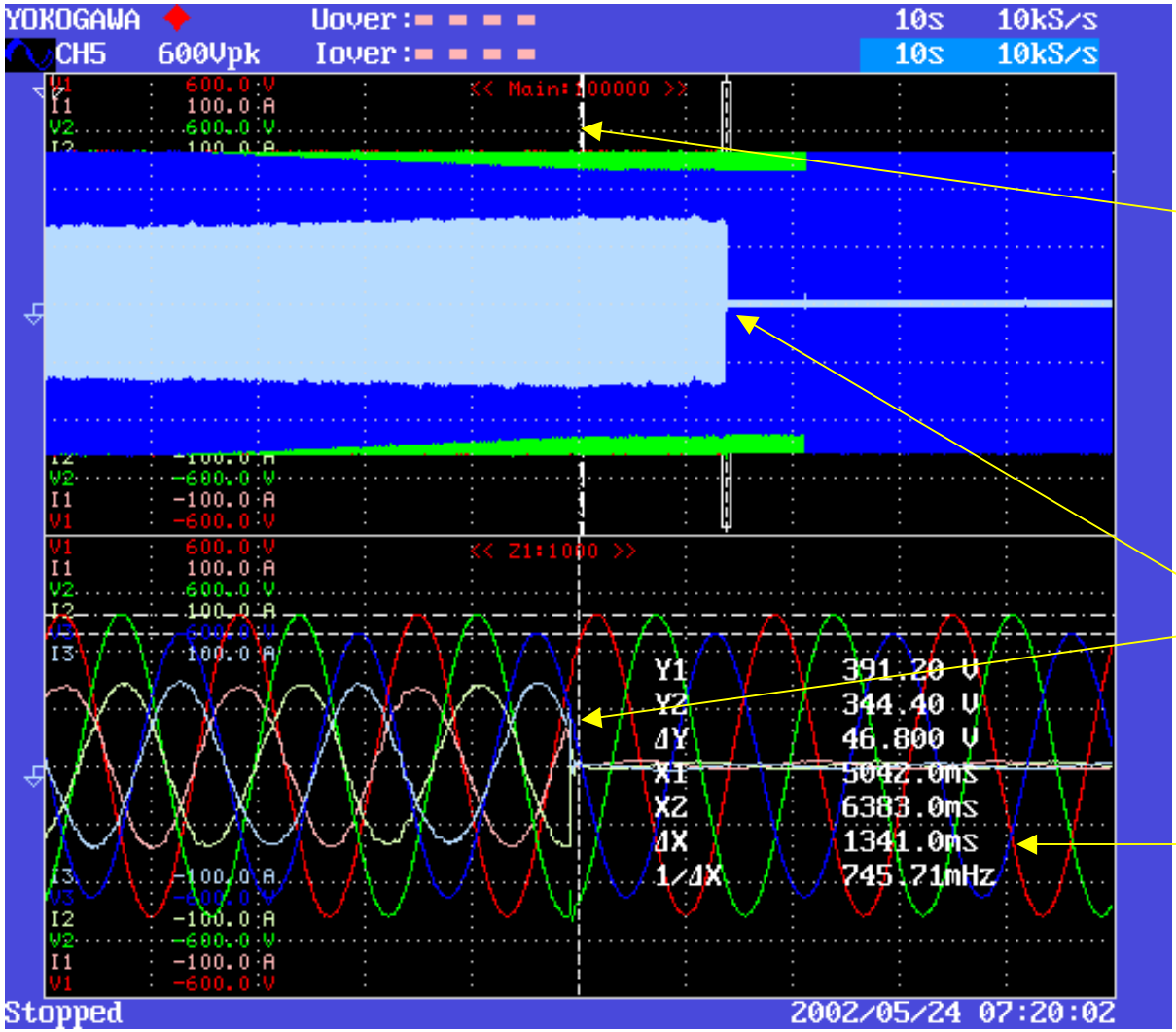
Measurement Period

Point of Disconnection

Frequency at disconnect = 60.42Hz


Over/ Under Voltage
Voltage (V)
700
600
500
400
300
200
100
0
0
2
4
6
8
Time (s)
120%
110%
88%
50%
Fast Over Voltage
Fast Under Voltage
Slow Over Voltage
Slow Under Voltage

Under Voltage Test Results

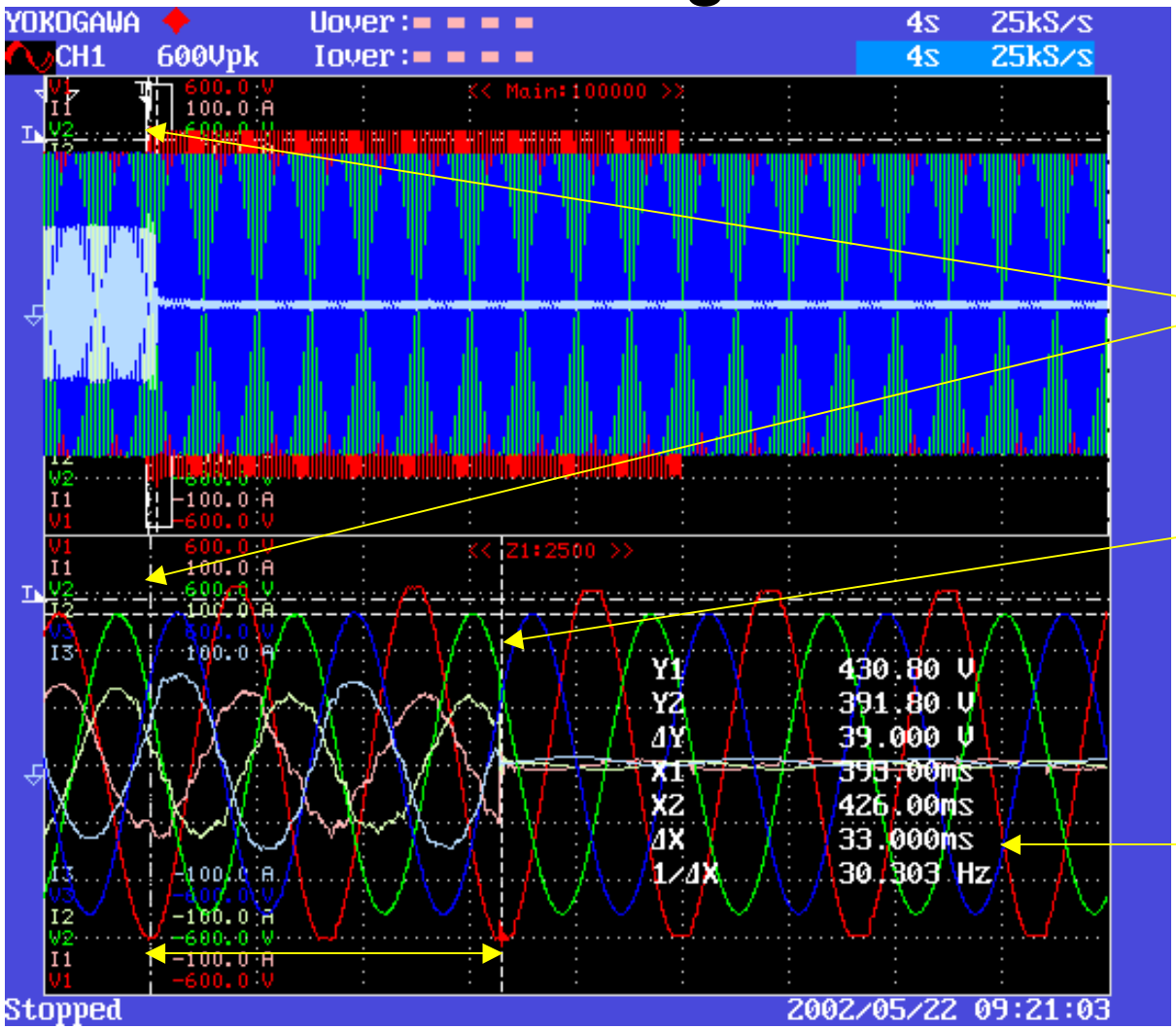


Start of 88% Under Voltage condition

Point of Disconnection

Time to disconnect = 1.34s

Over Voltage Test Results



Step to 120% OV

Start of over voltage condition

Point of Disconnection

Time to disconnect = 33ms

Anti-Islanding Tests

Data Acquisition

200kW Grid Simulator

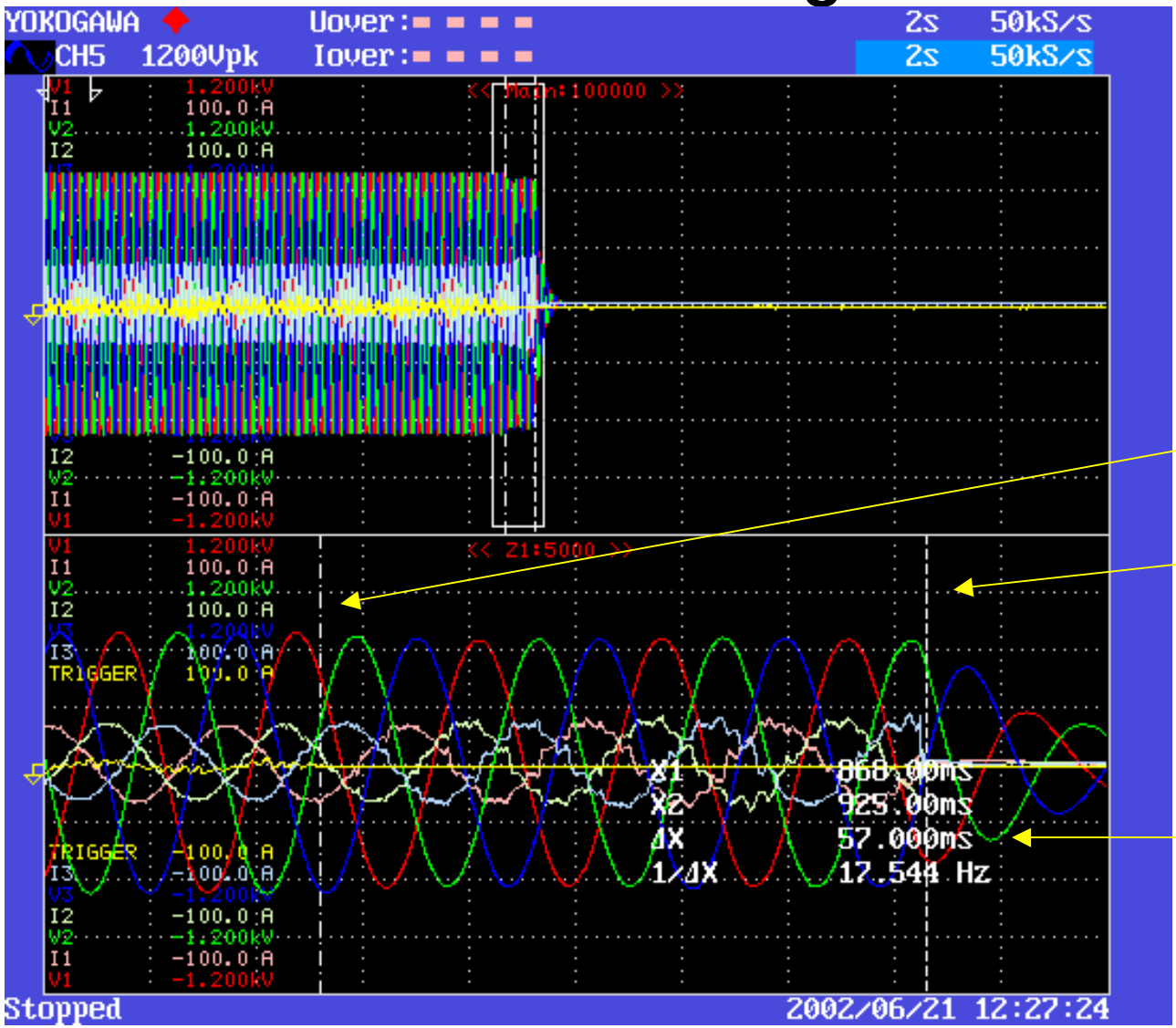
No current

Matched Load Q=2.5

RLC Load Bank

Capstone 330

Anti-Islanding Test Results



Matched Load

$P_{dr}=P_{load}$

$Q_{load}=2.5$

Open switch

DR Disconnect

Disconnect time = 57ms

IEEE P1589 – Test Updates

Test procedures are being developed for P1589 *"Standard Conformance Test Procedures for Equipment Interconnecting Distributed Resources with Electric Power Systems."*

Frequency and Voltage Test should be conducted in two parts to measure both time and value accuracy.

Future Planned Testing at DERTF

- Finish Capstone testing with updated test procedures
- ASCO SLTS – O/U voltage and frequency, anti-islanding
- Multi-DR Test – Test P1547 requirements with multiple DR (+15) interconnected
- GE Interconnection Device – P1547 tests

ASCO 7000 SLTS

125kW Genset